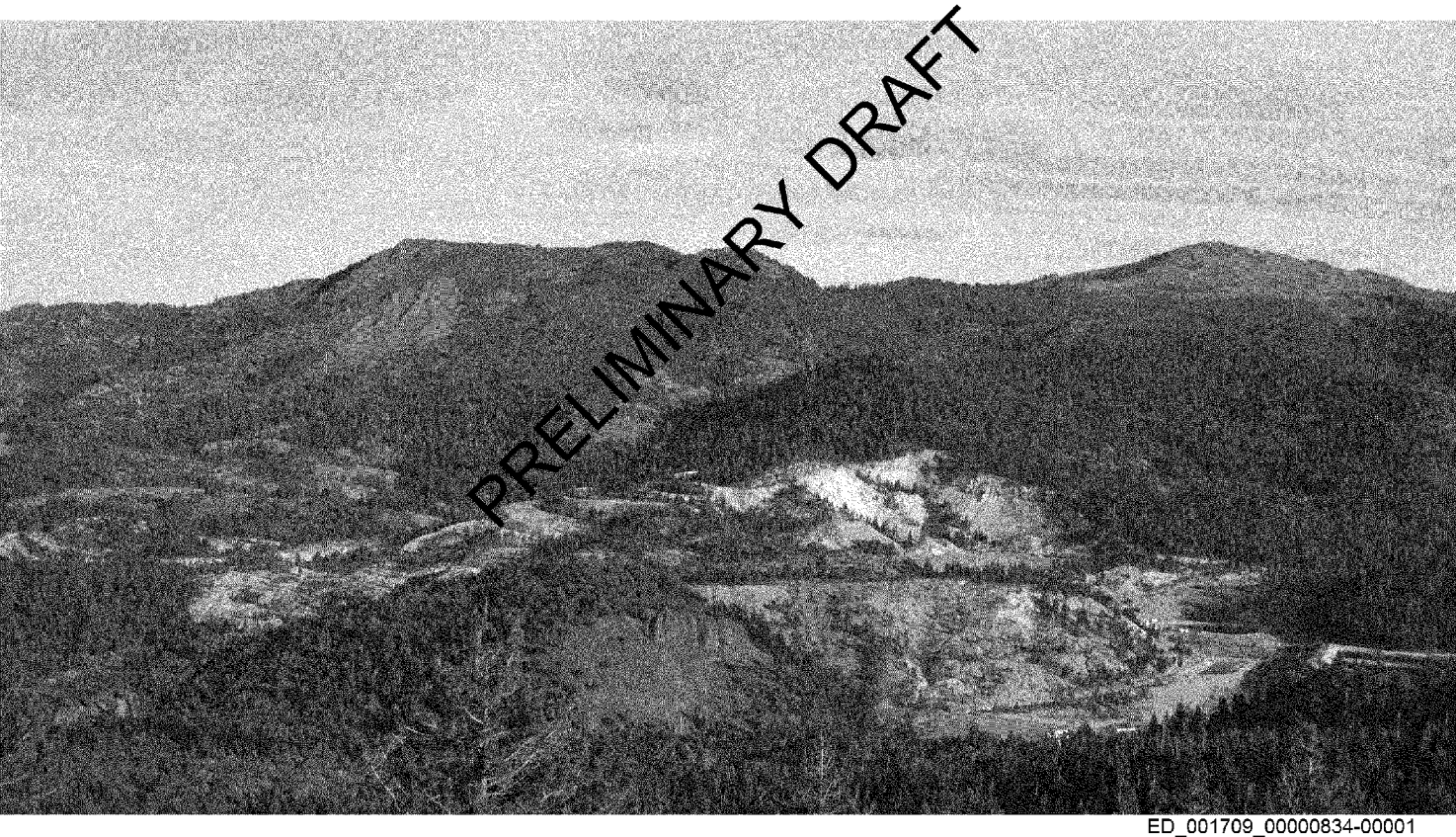
Overview of Sediment and Floodplain Soil Data

Leviathan Mine Site, Alpine County, California

December 13, 2016



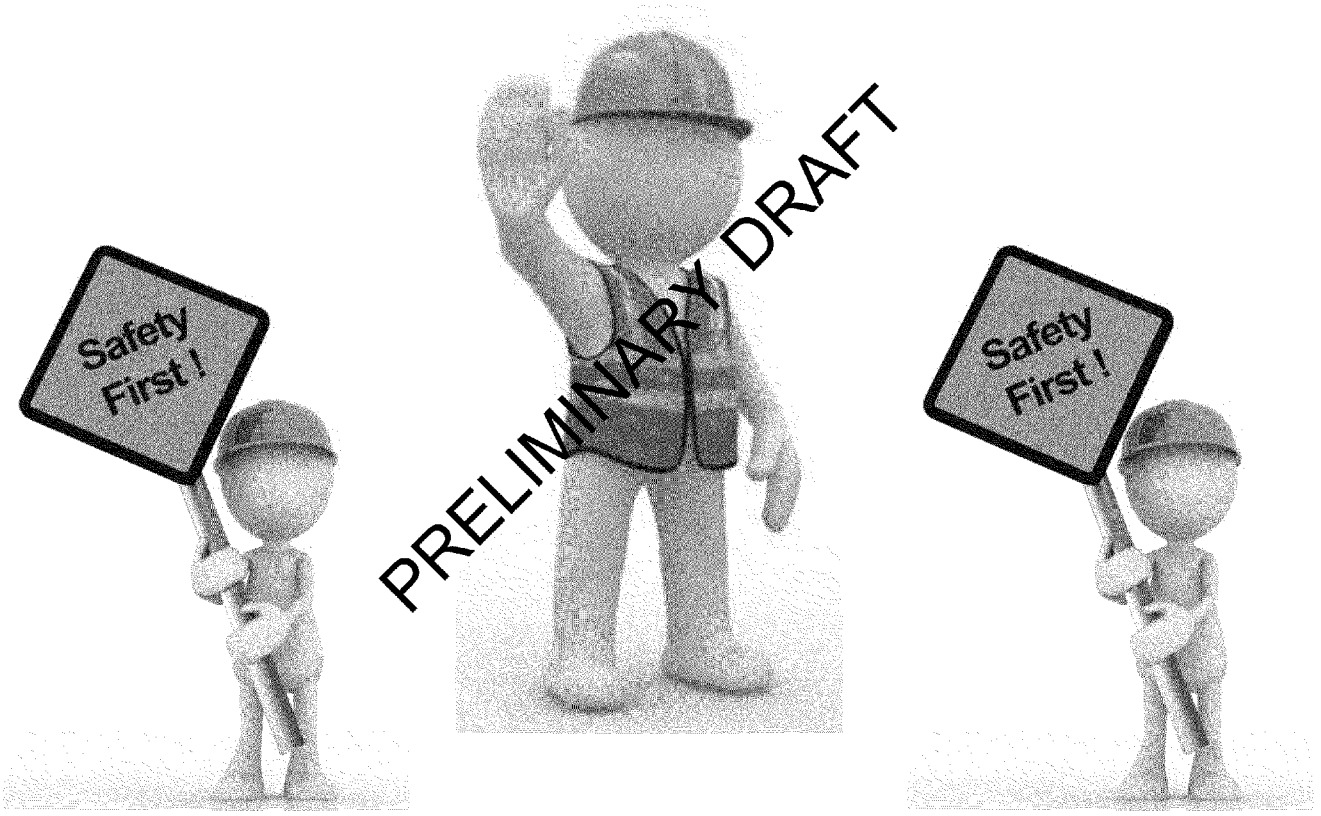
Presentation Outline (Morning Session)

- Safety Moment
- Terminology – Sediment vs. Floodplain Soil
- Status of Floodplain Soil Investigation
- Sediment Data
  - RI Sediment Data Quality
  - RI (Atlantic Richfield) Sediment Data
  - Other Sediment Data
- Conceptual Site Model for Sediment Metals
- Data Quality Objectives
- Sediment Study Design
- Stream Profiles for Selected Metals
- Primary Factors Influencing Metals Distribution
- Statistical Comparisons To Reference

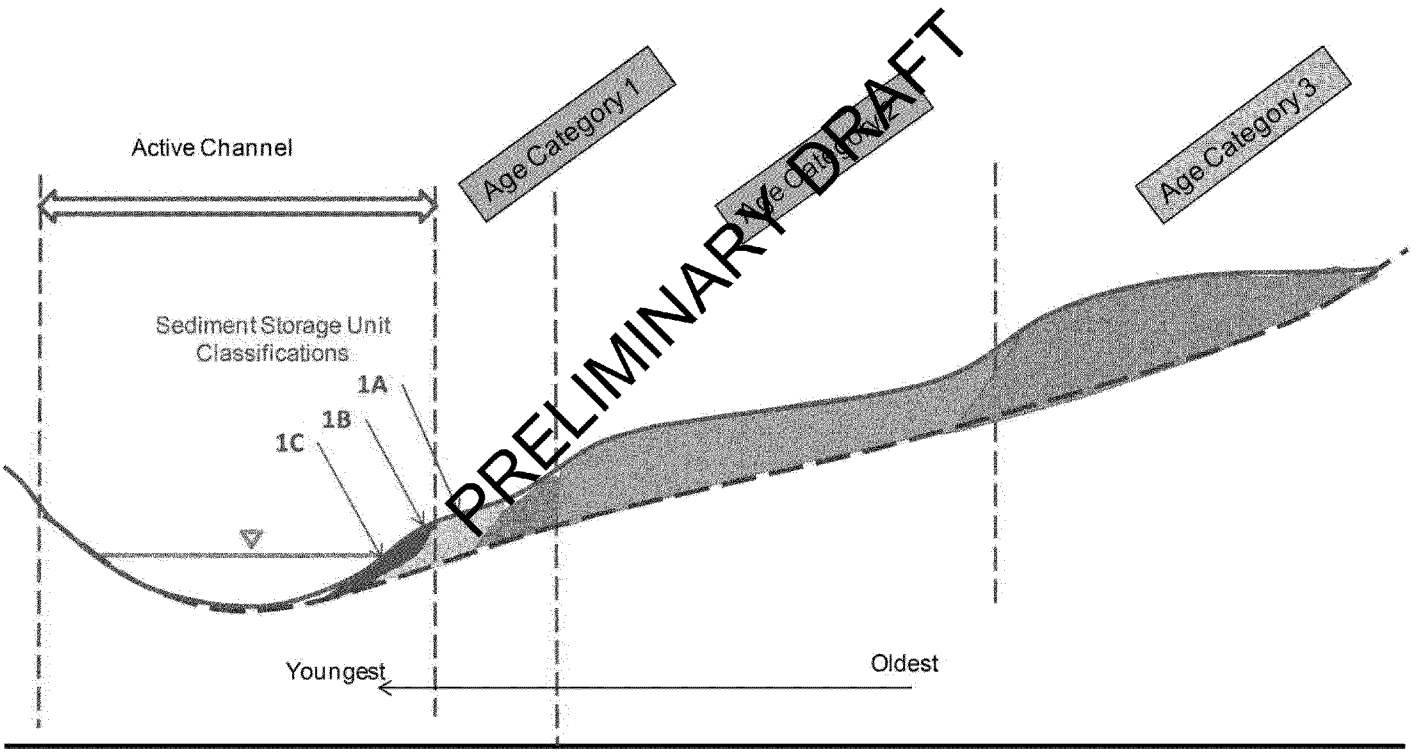
Discussion Outline (Afternoon Session)

- Schedule and Content of Interim RI Deliverables
  - Field Summary Reports (90 days after field work completed)
  - Technical Data Summary Reports (TDSRs)
- RI/FS Field Work Status
  - Remedial Investigation
  - Feasibility Study
  - Work Planned for 2017
- Next Steps and Wrap-Up

Safety Moment



Terminology: Sediment vs. Floodplain Soil



Chronology and Status of Floodplain Soil Investigations

Work Plan Development and Field Implementation

- 2010 – reconnaissance mapping of On-Property and Downstream Study Areas to identify relative age categories (Category 1, 2, 3) in support of the development of sampling design
- 2012 – detailed intrusive mapping of floodplain soils of soil characteristics in On-Property Study Area
- 2013 – reconnaissance mapping of Reference Study Areas to identify analogue areas for sampling
- 2013 – finalize Addendum No. 2 Off-Property Work Plan and obtained EPA conditional approval of phased sampling approach
- 2014 – no intrusive activities performed due to NHPA constraints
- 2015 – detailed intrusive mapping of soil characteristics in Downstream and Reference Study Areas
- 2015 – implemented floodplain soil sampling in On-Property Study Area and started sampling in Reference Study Areas
- 2016 – finalized work plans for floodplain soil sampling in Downstream and Reference Study Areas
- 2016 – completed floodplain soil sampling in Downstream and Reference Study Areas and conducted deeper sampling (to 6 feet bgs) in the On-Property Study Area

Current Status

- Laboratory analysis of samples collected in 2016 recently completed
- Data validation and data quality reviews of 2016 sampling data are underway

Summary of Floodplain Soil Sampling Design

Three Study Areas
(On-Property, Downstream Study Area, Reference Areas)

Study Areas Divided into Eight Reaches

- On-Property
  - **Aspen Creek** - 0.95-mile reach of Aspen Creek extending downstream from the property boundary to the confluence with Leviathan Creek
  - **Leviathan Creek** - 0.46-mile reach of Leviathan Creek between the upstream and downstream property boundary
- Downstream Study Area (DSA)
  - **Reach 1 (Leviathan Creek)** - 1.68-mile reach extending from the property boundary downstream to the confluence with Bryant Creek
  - **Reach 2 (Bryant Creek)** - 2.42-mile reach extending from the Bryant Creek headwaters (confluence of Leviathan and Mountaineer creeks) downstream to the confluence with Barney Riley Creek
  - **Reach 3 Upper (Bryant Creek)** - 3.16-mile reach extending downstream from the confluence with Barney Riley Creek to the confluence with Doud Creek
  - **Reach 3 Lower (Bryant Creek)** -1.78-mile reach extending downstream from the confluence with Doud Creek to the confluence with the East Fork Carson River
- Reference Study Areas (RSA)
  - **Upper Mountaineer Creek** - 1.81-mile reach extending from the headwaters of Mountaineer Creek to the confluence with Poison Creek
  - **Lower Mountaineer Creek** - 0.76-mile reach downstream of confluence with Poison Creek to confluence with Bryant Creek
  - **Cottonwood Creek** - 1.55-mile reach extending upstream from confluence with East Fork Carson River

Floodplain Soil Sampling Locations

PLACEHOLDER FOR MAPS SHOWING FLOODPLAIN TRANSECT AND SAMPLE LOCATIONS

RI Sediment Data (Atlantic Richfield 2013)

In 2013, in-stream and SQT sediment samples collected

- In-stream samples collected from July 8 through July 25, 2013 and September 24 through October 3, 2013
- SQT samples collected June 17 through June 27, 2013, and September 30 through October 4, 2013 (two sampling events)
- Samples collected by hand using stainless steel sampling equipment

In-stream sediment samples

- Samples collected from 0 to 3 cm
- Bulk samples submitted for RI/FS metals, TOC, AVS, and AVS/SEM metals, and particle-size distribution analysis
- Samples collected from 84 locations in the DSA (Leviathan and Bryant creeks)

SQT sediment samples

- During the first sampling event, samples collected from the upper 10 cm, during the second sampling event, samples collected from 0 to 3 cm
- Bulk samples submitted for bioassay testing, RI/FS metals, TOC, AVS, AVS/SEM metals, and particle-size distribution analysis
- Samples collected from 8 locations during each event in Aspen, Leviathan, Bryant, and Mountaineer creeks

RI Sediment Data (Atlantic Richfield 2015)

In 2015, sediment samples collected On-Property and RSA

- On-property samples collected from September 3 through September 15, 2015, and September 28 through October 27, 2015
- RSA samples collected September 29 through October 26, 2015
- Samples collected from 0 to 3 cm
- Bulk samples submitted for RI/FS metals, TOC, AVS, and AVS/SEM metals, and particle-size distribution analysis
- Samples collected by hand using stainless steel sampling equipment

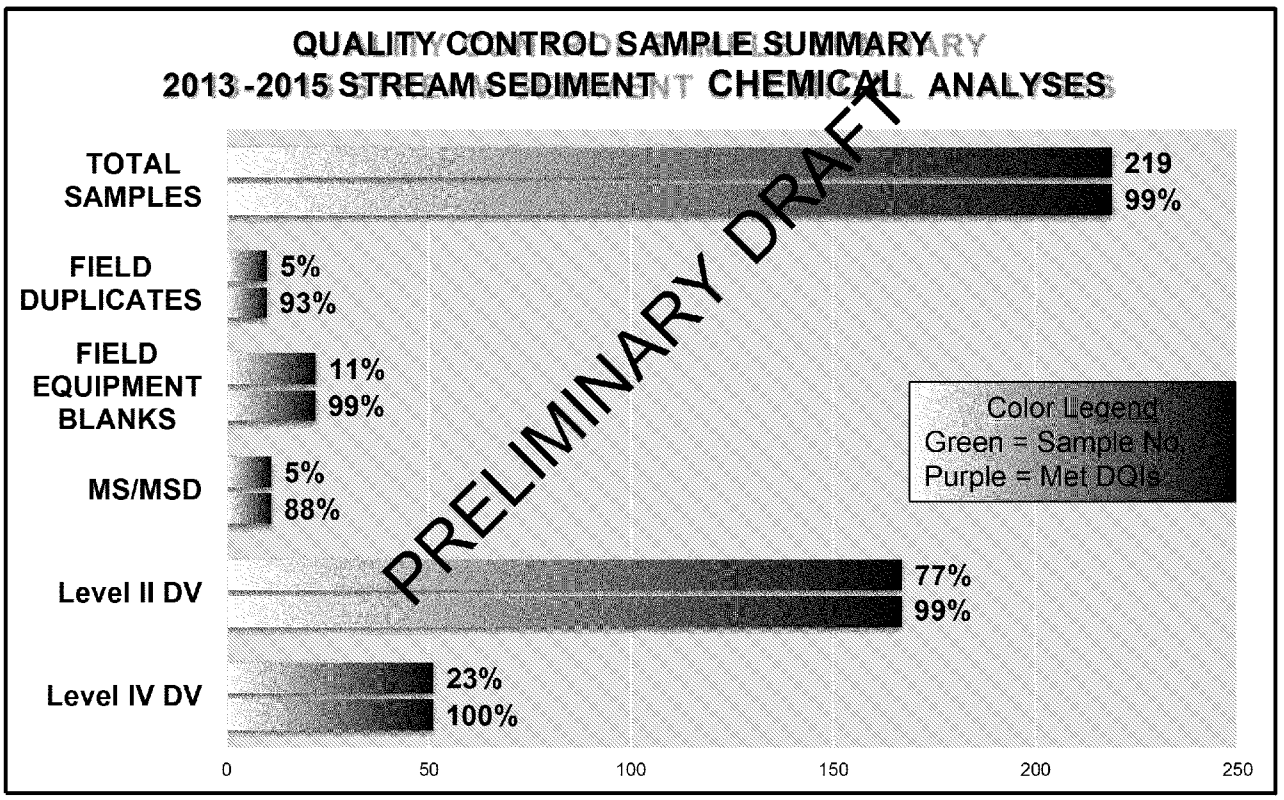
On-Property sediment samples

- Samples collected from 30 locations in Aspen and Leviathan creeks
- Samples also collected from 4 locations in the BDPC on Leviathan Creek

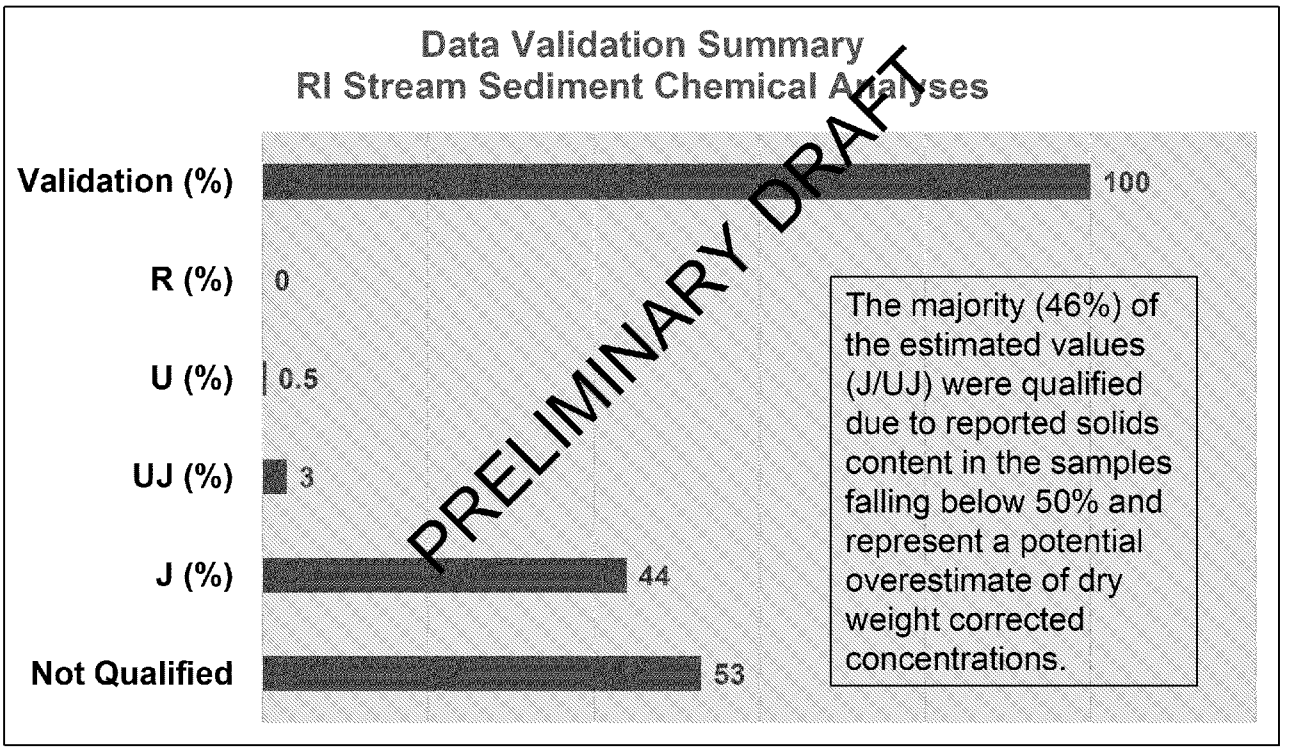
RSA sediment samples

- Samples collected from 50 locations in Cottonwood and Mountaineer creeks

RI Sediment Data Quality



RI Sediment Data Quality



RI Sediment Data Usability

Data Use in Analysis

- Estimated values (flagged J or UJ) are used as the reported value for the purposes of statistical calculations and geostatistical evaluations
- Laboratory results reported as non detect (< RL) or qualified as U at an adjusted RL are used in statistical calculations at a value equal to the RL
- Only results from primary samples have been used for statistical calculations and geostatistical evaluations. Field duplicate samples (FD) have been retained in the database, but are not used in this evaluation

Other Sediment Data

EPA Sediment Data Collected by Ned Black's Team

- Annual sampling (once or twice per year during June and/or September)
- Surficial sediment (0 to3 cm) available from Sept. 2000 through Sept. 2013
- 16 sites sampled consistently; occasional samples at other sites
- 19 RI/FS metals (No hexavalent chromium)

Dave Herbst Index of Biotic Integrity for Benthic Community

- Index comprised of 10 metrics that measures the health of benthic community
- Score ranges from 0 to 10. Higher values represent worsening condition
- Annual sampling (once or twice per year during June and/or September)
- Sampling data from 1995 to present – data available only through 2014
- Samples only from riffle habitat
- Provides indirect information on sediment metal's bioavailability

Herbst Index of Biological Integrity Monitoring

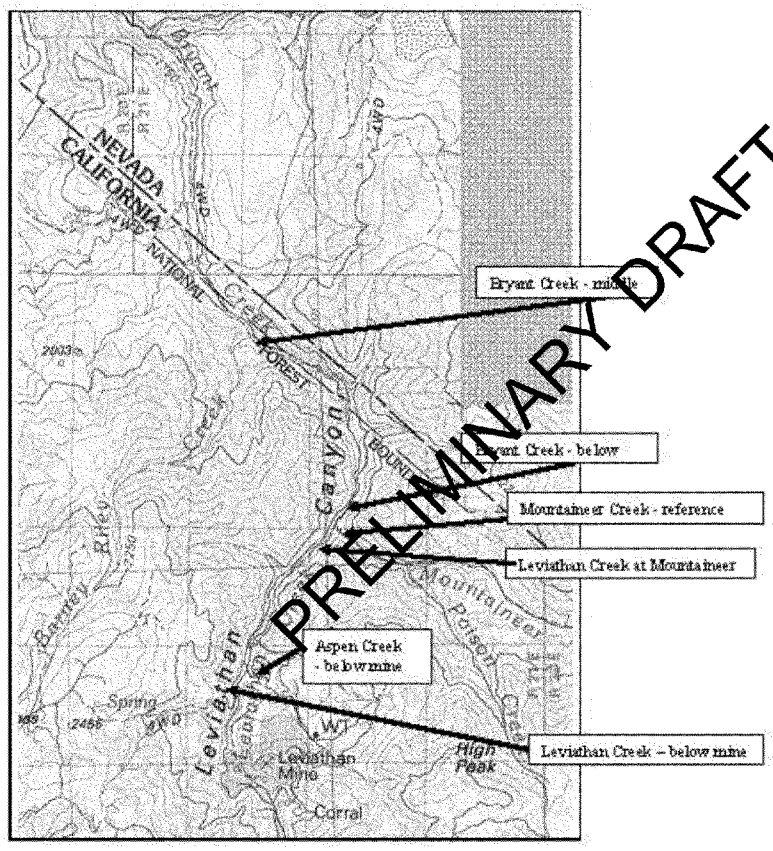
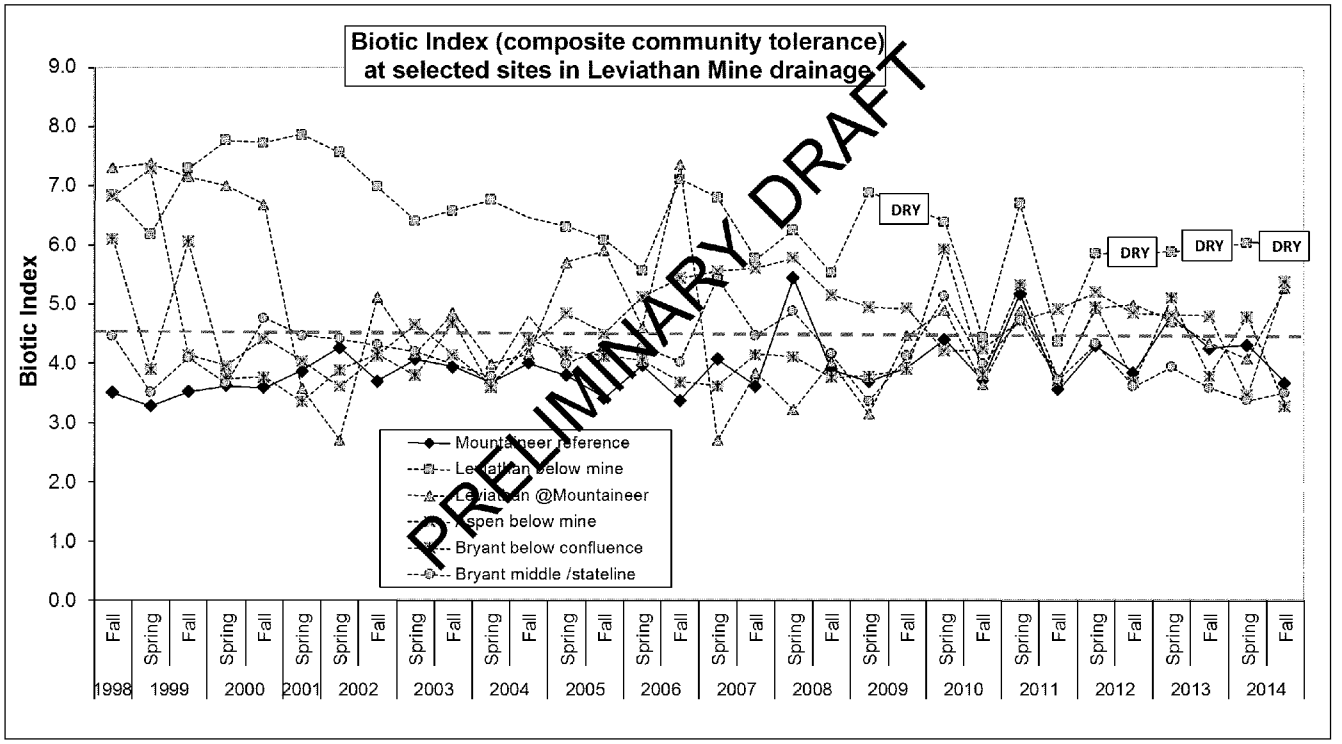
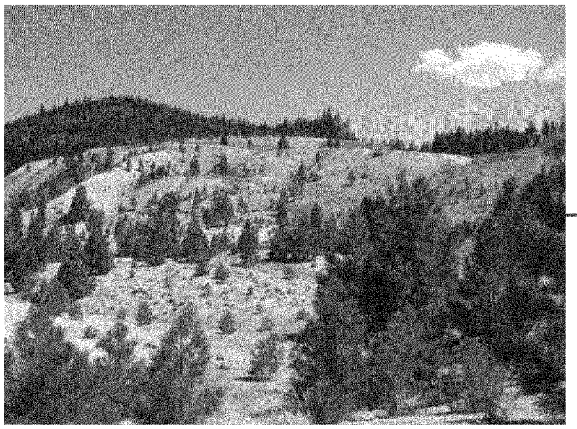


Figure 1. Locations of key sample sites surveyed for aquatic invertebrate biomonitoring of the Leviathan Mine watershed.

Herbst Index of Biological Integrity Monitoring



Sediment Conceptual Model



Waste Rock Weathering – Pyrite Oxidation

- Enhanced by small particle size of mine waste
- Primary end products – sulfate, iron, proton acidity
- Mobilizes other trace metals

Hydroxide Formation & Precipitation

- Increasing surface water pH downstream leads to iron and aluminum hydroxide formation, precipitation, and sediment deposition
- Trace metals adsorbed onto precipitated iron and aluminum hydroxides

Primary Sources

- Mine waste
- In situ Rock

Sedimentation

- Higher metal concentrations associated with the fine grain fraction (e.g. hydroxides, silts & clays)
- Fine grain fraction preferentially deposited in low energy vs. high energy environments (e.g. pools vs. cascades)

Mine Waste Erosion

- Transport of mine waste and downstream deposition

Summary of Data Quality Objectives: Stream Sediment/Floodplain Soil Investigations

Step 1 - Problem Statement:
Extent and magnitude of COPCs/COPECs in stream sediment/floodplain soil in the On-Property Study Area are not sufficiently understood to make comparisons to reference concentrations and ARARs, evaluate risk to human or ecological receptors, and evaluate the need for future remedial action.

Step 2 - Study Question:
Is stream sediment/floodplain soil chemistry in the On-Property Study Area sufficiently characterized for the purposes of comparisons to reference concentrations and ARARs, supporting human health and ecological risk evaluation, and evaluation of remedial alternatives if necessary?

Step 3 – Information Inputs:
- Location and extent of depositional and non-depositional features and relative ages of floodplain soils
- Location and extent of sediment bedforms (pool, riffle, glide, step pool, and cascade)
- Floodplain soil classification, grain size, mineralogy
- Extent of armoring and bank configuration (stability, topography)
- Stream sediment chemistry (RI/FS metals, general chemistry, AVS/SEM,etc)
- Chemical-specific ARARs
- Screening level risk benchmarks

Step 4 – Define Boundaries:
- Stream sediment and floodplain soils in On-Property reaches of Leviathan and Aspen Creeks
- Stream sediment and floodplain soils in the Downstream Study Area (Leviathan and Bryant Creeks)

Summary of Data Quality Objectives: Stream Sediment/Floodplain Soil Investigations

Step 5 – Analytical Approach:
If RI/FS metals concentrations and other general chemistry parameters in stream Sediments and floodplain soils are obtained from representative depositional environments, these chemistry data can be used to evaluate human health and ecological risk, comparison to ARARs and reference concentrations, and evaluate remedial alternatives if necessary.

Step 6 – Acceptance Criteria:
Data collection goal is to characterize range and distribution of RI/FS metals concentrations and other general chemistry parameters in stream sediments and floodplain soils. A multiple lines of evidence evaluation of each dataset will be conducted using professional judgment and exploratory data analysis methods to assess the spatial and temporal variability in the chemical data for the media of interest to ensure that the datasets are representative and have an adequate sample size.

Both qualitative and quantitative acceptance criteria will be considered.

Qualitative criteria will consider whether:
(1) investigative samples were collected for targeted environmental media and analyzed for RI/FS metals,
(2) investigative samples were collected within areas that are considered representative of the investigation area, and
(3) investigative samples were collected over time periods that are representative of temporal variability in site conditions, if applicable.

Summary of Data Quality Objectives: Stream Sediment/Floodplain Soil Investigations

Step 6 - Acceptance Criteria (continued):

Quantitative criteria to be evaluated prior to the comparison of datasets in statistical analyses will consider whether:

(1) detectable concentrations of individual RI/FS metals were present in more than four samples in sample populations with less than 40 samples or the frequency of detection of individual RI/FS metals was greater than 10 percent in sample populations with more than 40 samples,

(2) the dataset consists of 10 or more samples representative of a specific medium, and

(3) the dataset represents a single population as determined by exploratory data analysis.

Comparison to Chemical-Specific ARARs or TBCs

Null hypothesis: The concentrations of RI/FS metals in media in potentially affected areas of the On-Property and Off-Property study areas **are significantly greater** than chemical-specific ARARs (e.g., MCLs) or TBCs (e.g., screening risk levels).

Comparison to Reference Concentrations

Null hypothesis: The concentrations of RI/FS metals in media in potentially affected areas of the On-Property and Off-Property study areas **are significantly greater** than reference concentrations.

Acceptance Criteria: The limits of the likelihood of making decision errors are calculated to be: Type 1 error, false rejection at 0.05 (95 percent confidence level); and Type 2 error, false acceptance at 0.20 (80% confidence level).

Summary of Data Quality Objectives: Stream Sediment/Floodplain Soil Investigations

Step 7 – Study Design:

Preliminary Investigations

Reconnaissance mapping of the location and extent of stream sediment and floodplain soil depositional areas

Detailed Investigations – Stream Sediment

- Use professional judgment to establish location and extent of in-channel environments based on the sediment mapping completed in 2012
- Collect stream sediment samples within stream thalweg from 0 to 3 cm in wetland, glide, pool, step pool, cascade, and vegetated channel environments
- Conduct laboratory analysis of RI/FS metals, AVS/SEM, TOC, and grain-size distribution.

Detailed Investigations – Floodplain Soil

- Use professional judgment to select transects/locations where there is likely to be 2 feet or more of fine-grained soil. Establish transects for sampling of age-category 1, 2, and 3 floodplain soils.
- Perform FPXRF analysis in surficial soil samples (approximately 0 to 6-inches) of the mapped soil types to identify the variability within and among the floodplain soil deposit.
- Collect floodplain soil samples at depths up to 6 feet bgs at 3 locations along each transect.
- Conduct laboratory analysis of RI/FS metals, general chemistry, TOC, and grain-size distribution.

Sediment Study Design (Spatial Distribution)

Three Study Areas
(On-Property, Downstream Study Area, Reference Areas)

Study Areas Divided into Eight Reaches

- On-Property
  - **Aspen Creek** - 0.95-mile reach of Aspen Creek extending downstream from the property boundary to the confluence with Leviathan Creek
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STUDY REACHES

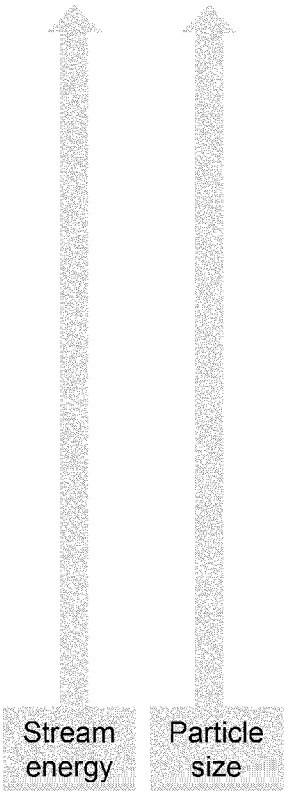
PLACEHOLDER FOR MAPS SHOWING STUDY REACHES

REFERENCE STUDY REACHES

PLACEHOLDER FOR MAPS SHOWING REFERENCE STUDY REACHES

Sediment Study Design (Channel Type)

Channel Unit	Description
Cascade	A high-gradient segment of the stream with tumbling flow.
Riffle	A shallow and fast segment of the stream with visible turbulence and coarser substrates.
Glide	A shallow- to mid-depth segment of the stream with fast but laminar flow.
Step-Pool	A series of small pools and drops formed either by aggregation of large clasts or wood debris.
Pool	A deep and slow segment of the stream formed either by scour or damming.
Vegetated Channel	A confined and homogeneous segment of the stream with vegetation growing in the active channel, typically human-modified
Wetland	An unconfined segment of the stream where flow diffuses into multiple channels and across a broad vegetated area.
Beaver Pond	A backwatered segment of the stream where water level is controlled by a beaver dam, typically larger than a pool.



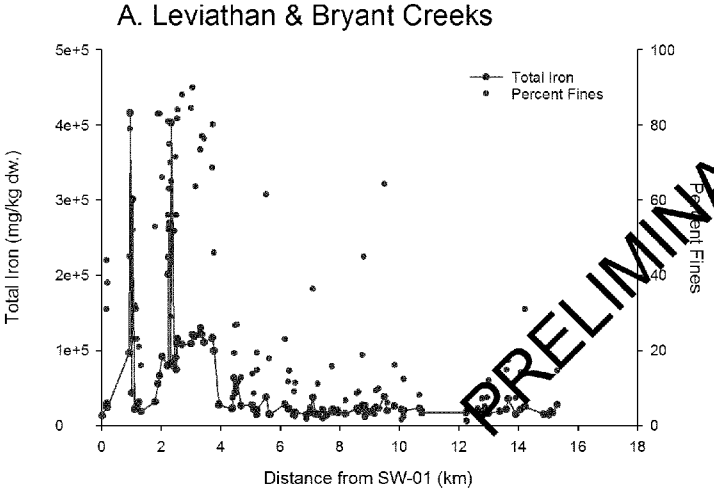
Sediment Study Design (Channel Types)

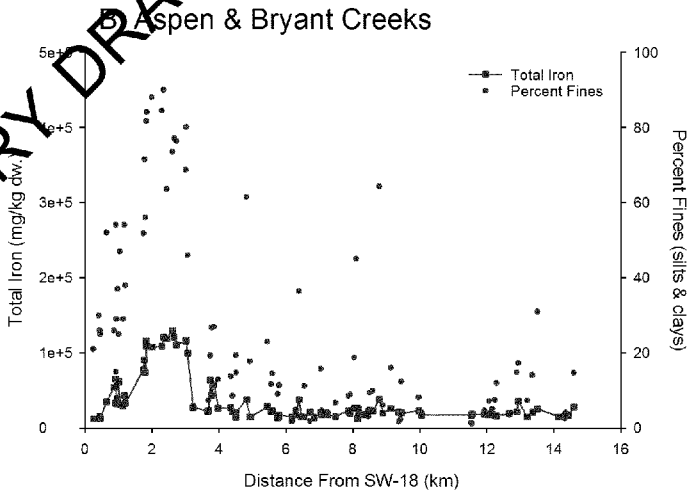
	On-Property			DSA Reaches					Reference Study Area				
Channel Units	Aspen	Leviathan	On-Property Subtotal	1	2	3U	3L	DSA Subtotal	Lower Mountaineer	Upper Mountaineer	Cottonwood	RSA Subtotal	Grand Total
Cascade	3	3	6							1	6	7	13
Glide	3	1	4	5	9	5	1	20	1	3	6	10	34
Pool		3	3	4	4	2	1	11	4	1	6	11	25
Riffle		6	6	9	5	5	1	[illegible]	4	3	6	13	39
Step pool	3	2	5	6	6	5	2	19	6		3	9	33
Vegetated Channel	3	3	6										6
Wetland	3	3	6										6
Beaver Pond		4	4		[illegible]		1	14					18
Grand Total	15	25	40	24	[illegible]	24	6	84	15	8	27	50	174

Channel Type Sampling Locations

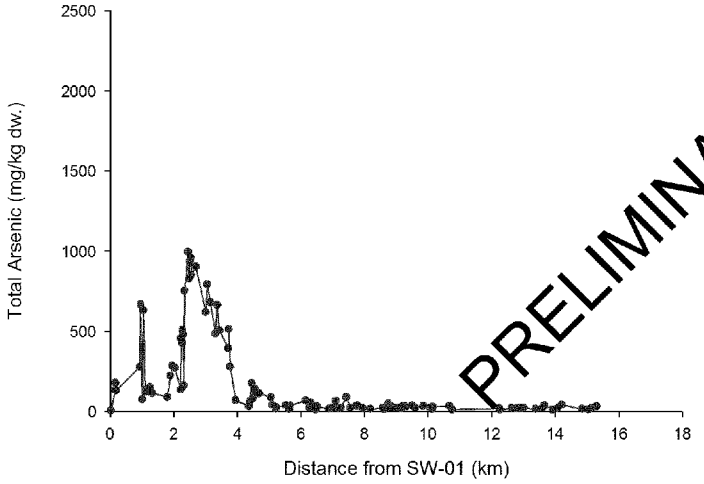
PLCEHOLDER FOR MAPS SHOWING SAMPLING LOCATIONS

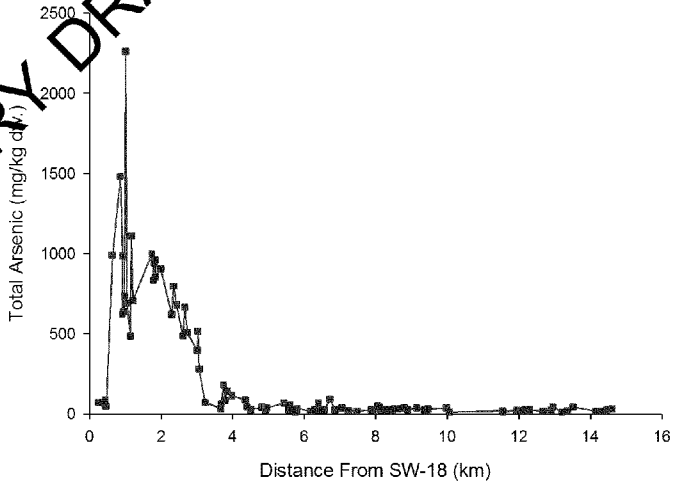
Stream Profiles of Total Iron & Percent Fines



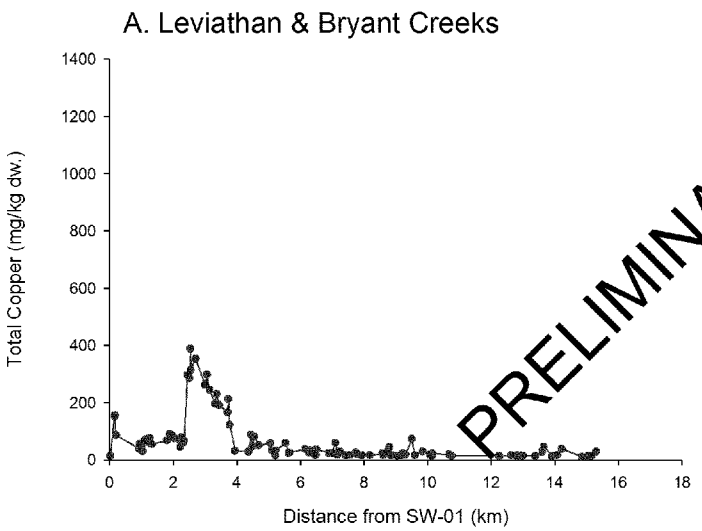


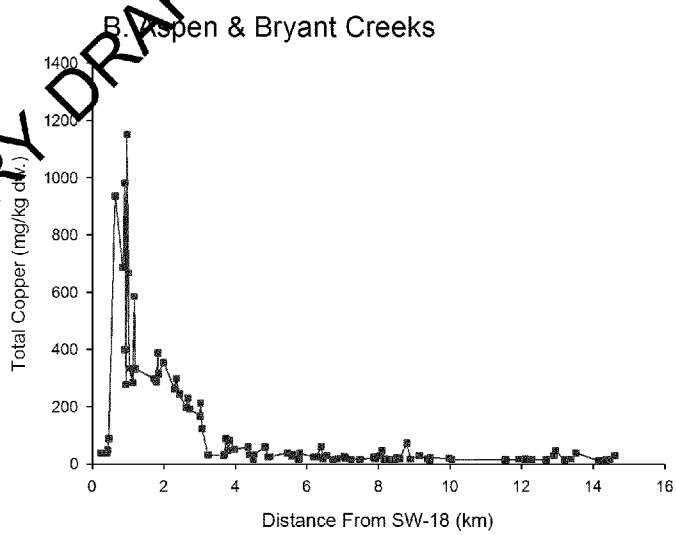
Stream Profiles of Total Arsenic



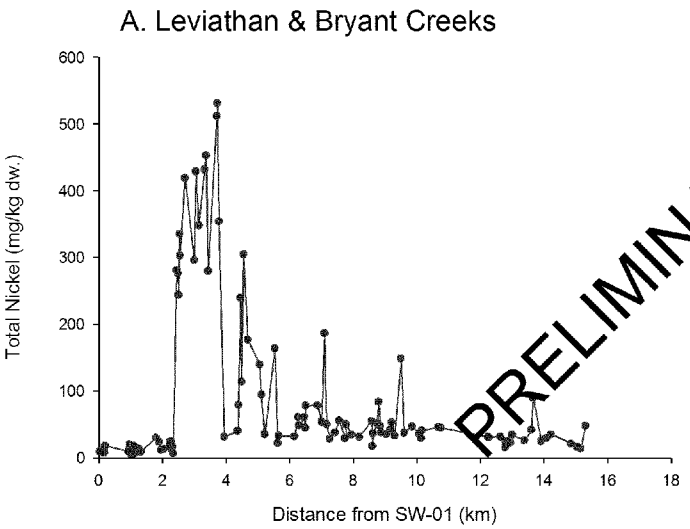


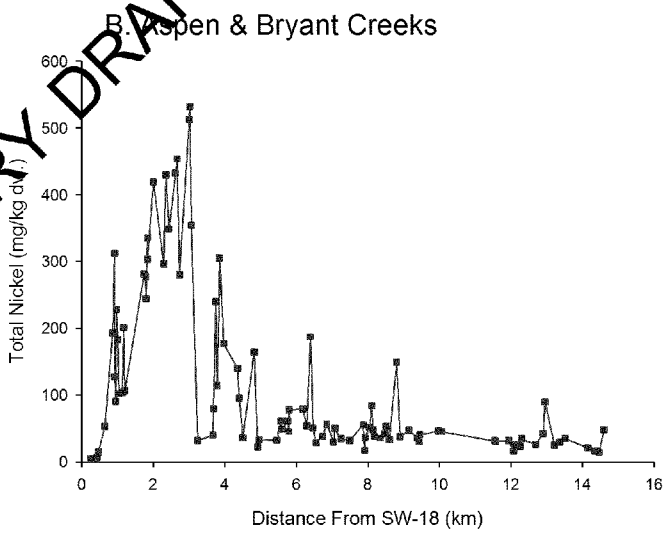
Stream Profiles of Total Copper



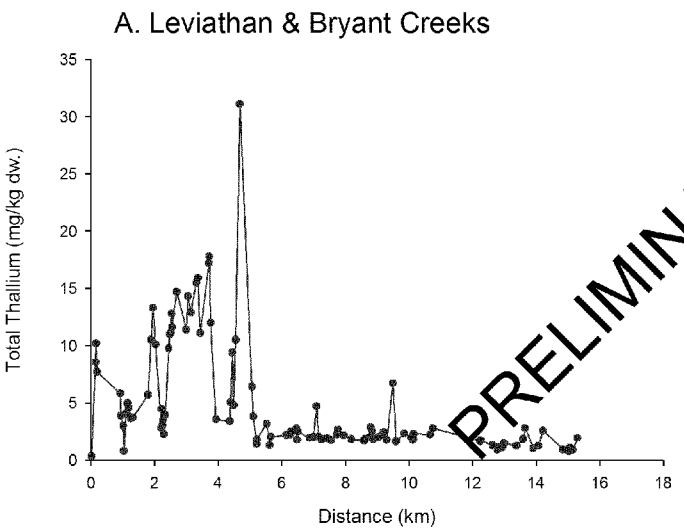


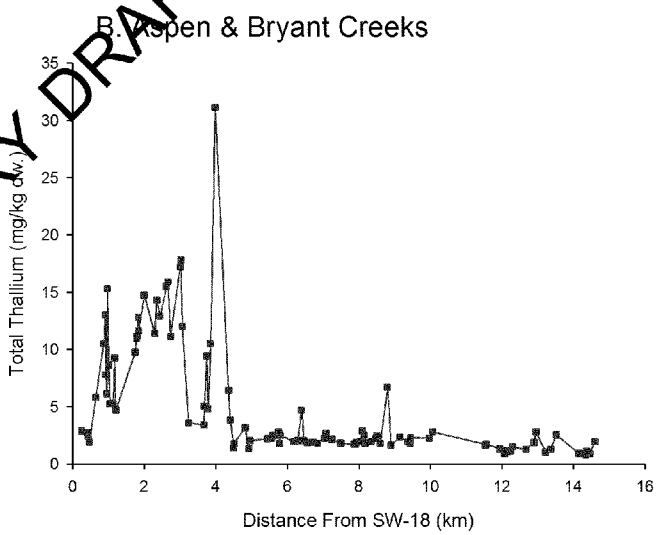
Stream Profiles of Total Nickel



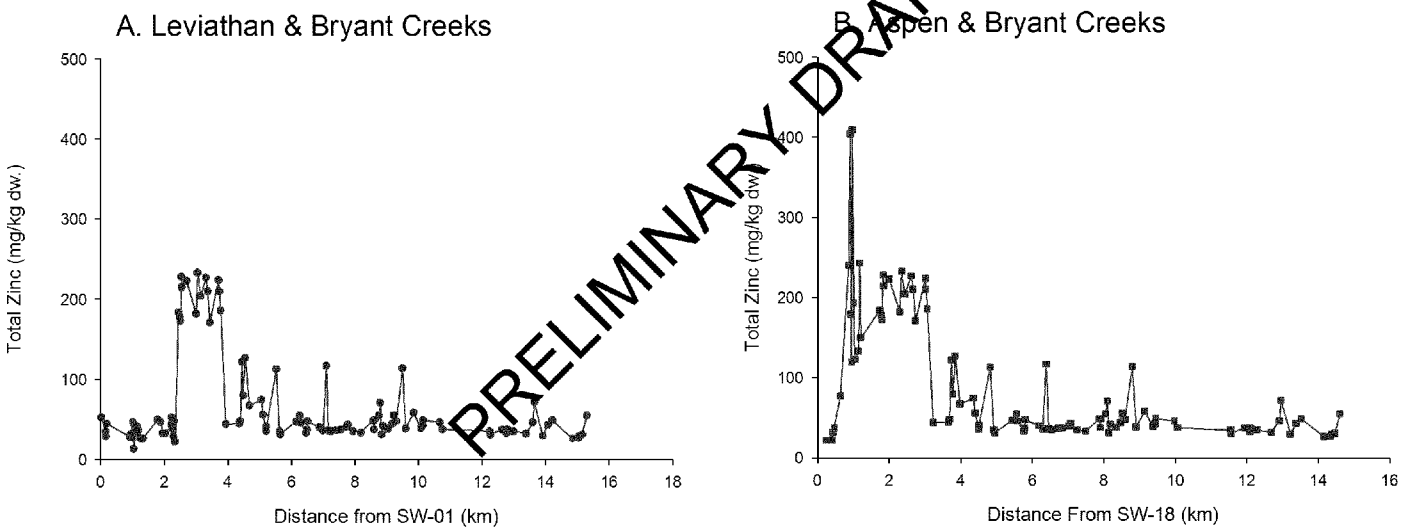


Stream Profiles of Total Thallium

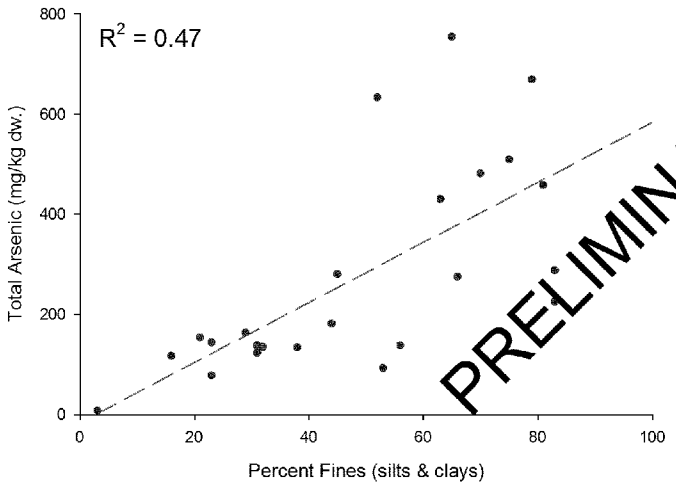


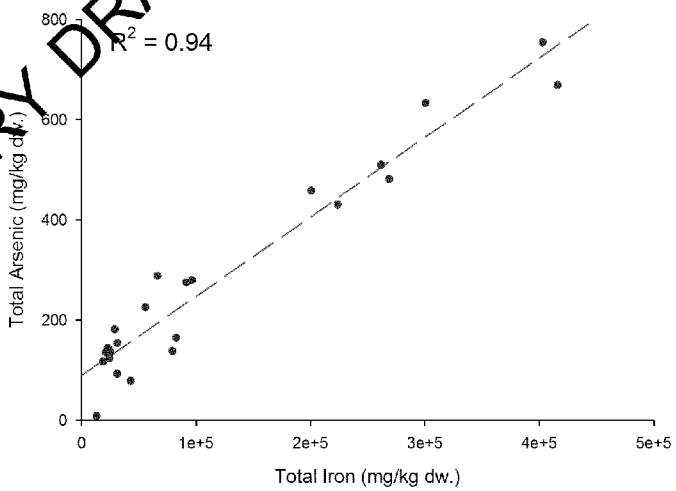


Stream Profiles of Total Zinc



Total Arsenic vs. Percent Fines and Total Iron





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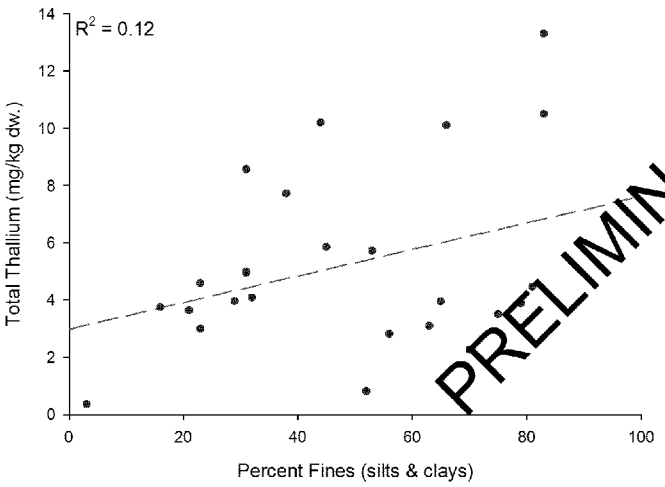
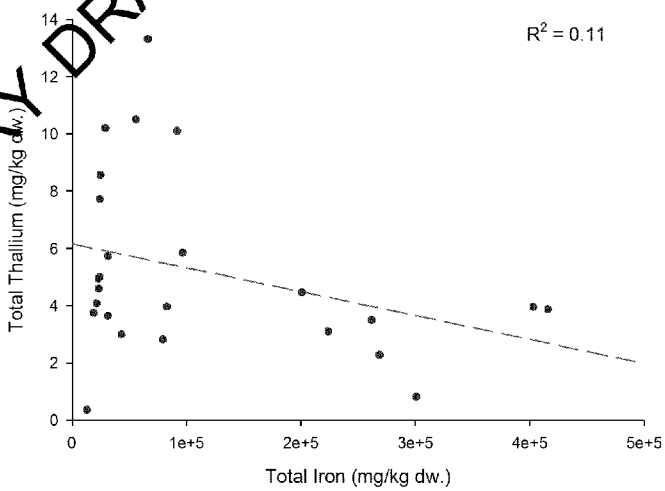
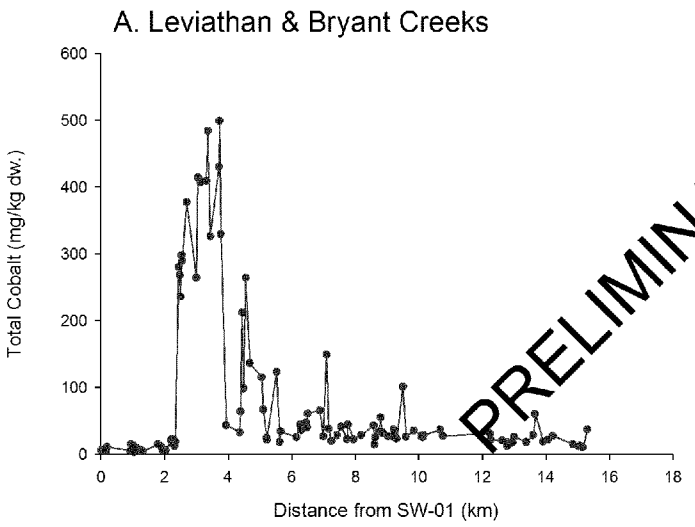
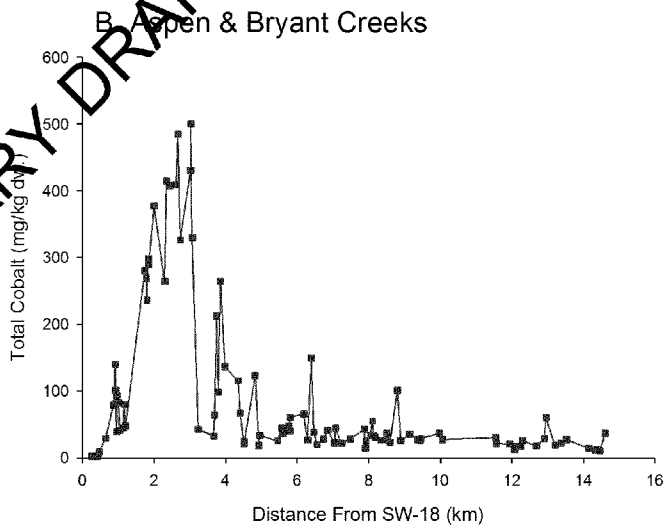


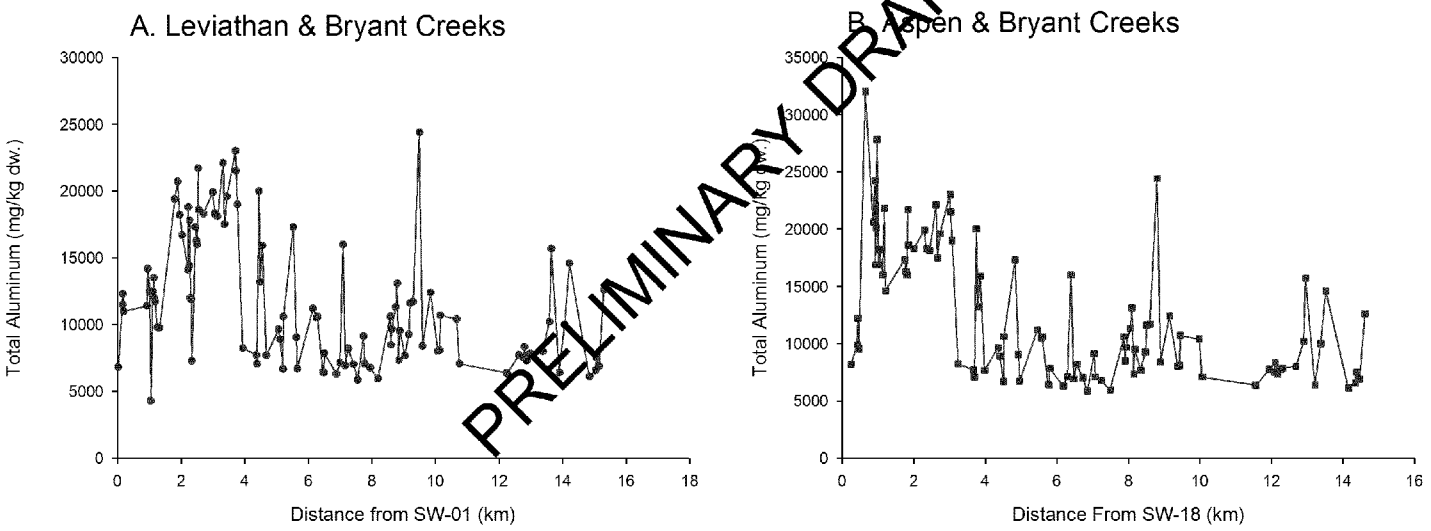


Stream Profiles of Total Cobalt

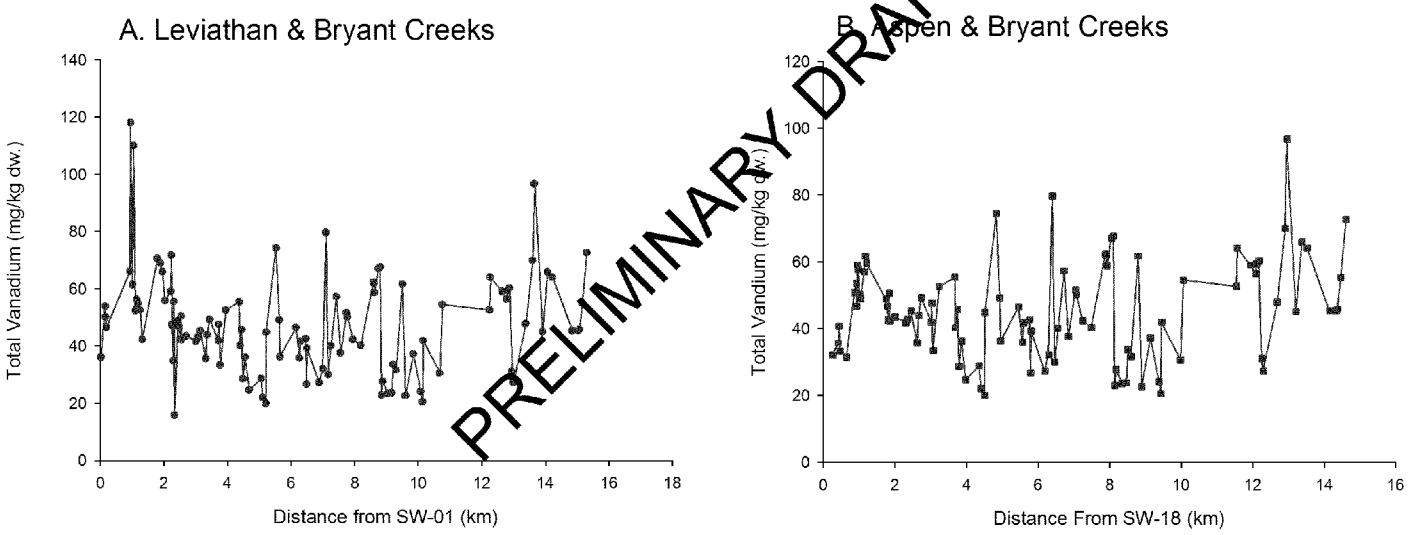




Stream Profiles of Total Aluminum



Stream Profiles of Total Vanadium



Preliminary Statistical Comparisons

Nonparametric statistical tests

- Does not require assumptions of normality and homogeneity of variance
- No outlier removal
- Kruskal–Wallace test for comparing more than two sites
- Mann–Whitney test for comparing two sites
- Significance level = $p < 0.05$

Statistical comparisons

- Metals correlation with grain size (percent fines: < 63 µm diameter)
- Grain size versus channel type
- Metal concentration comparisons among three reference reaches
- On-Property and DSA reach comparisons to reference reaches

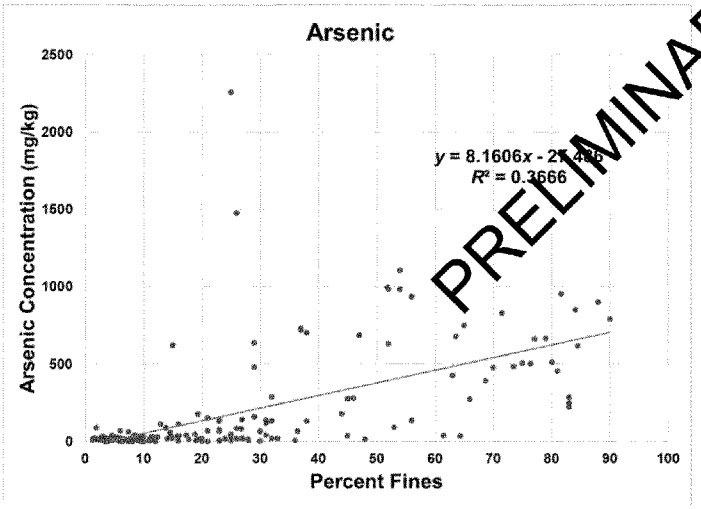
Metals Correlation with Grain Size

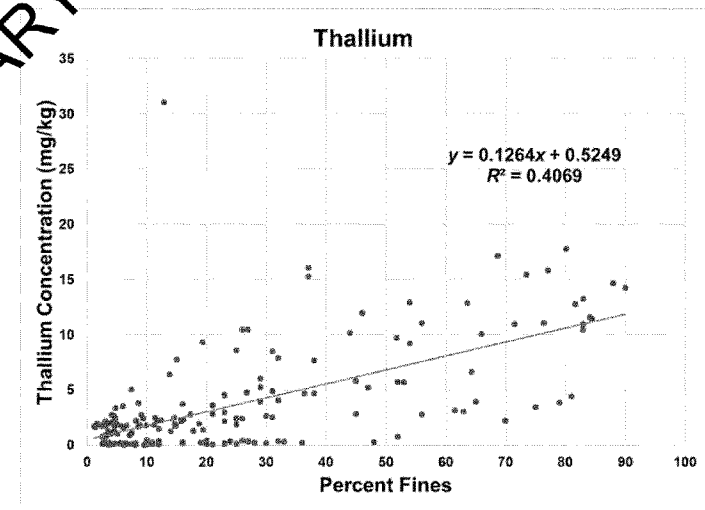
Significant positive correlation with percent fines (silt & clay) ($p < .05$)

- Al, Sb, As, Ba, Be, Cd, Cr, Cr^{+6}, Co, Cu, Fe, Pb, Mn, Hg, Ni, Se, Ag, Tl, Zn

No significant correlation with percent fines ($p > .05$)

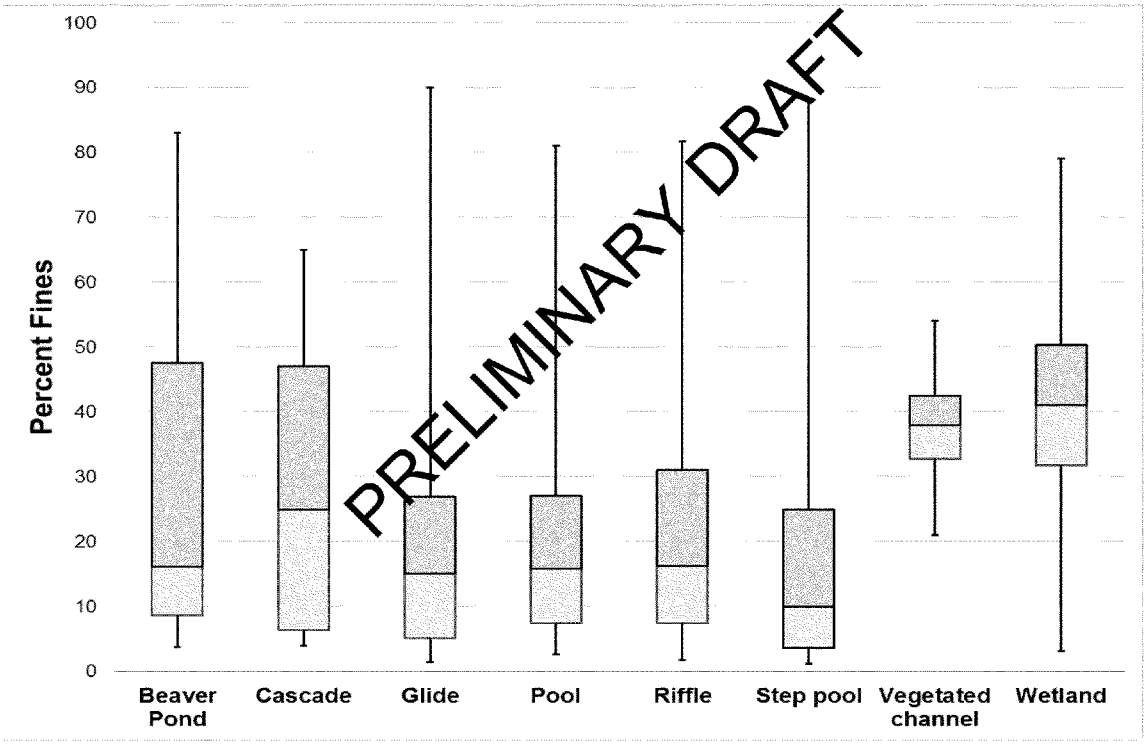
- V





Grain Size Versus Channel Type

No significant difference in grain size (percent fines) among channel types



Comparisons among Reference Reaches

Highly significant difference among three reference reaches ($p < 0.1$)

- Al, As, Ba, Be, Cd, Cr^{+6}, Co, Cu, Fe, Pb, Mn, Hg, Ni. Se, Ag, Tl, Zn

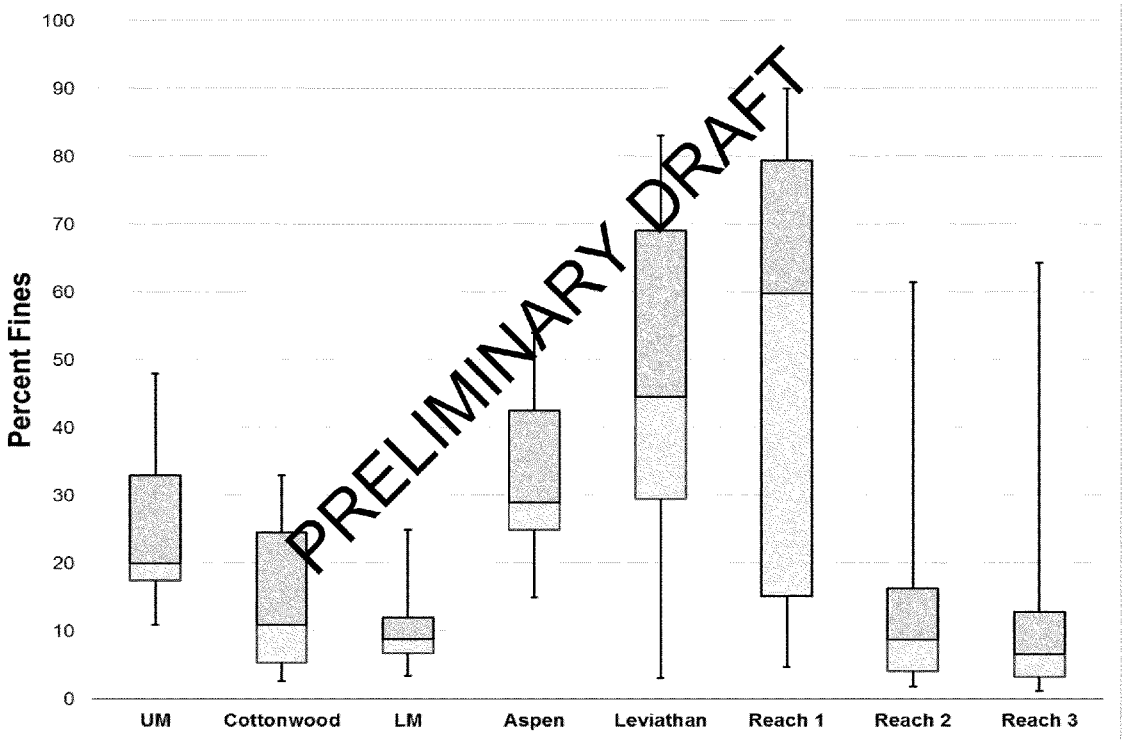
No significant difference among reference reaches ($p > .05$)

- Sb, Cr, V

Conclusions

- Reference sediment data were not pooled for comparisons to on-property and DSA reaches
- Differences can be attributed to grain size

Grain Size versus Study Reach



Next Steps:
Stream Sediment/Floodplain Soil Investigations

Stream Sediment

- ☐ Complete spatial evaluation of stream sediment data collected by Atlantic Richfield
- ☐ Conduct comparison to EPA stream sediment sampling results
- ☐ Estimate reference threshold concentrations for reference reaches
- ☐ Complete weight of evidence evaluation of SQT results
- ☐ Complete interpretation of results of statistical comparisons and other lines of evidence
- ☐ Conduct comparison to risk-based screening levels
- ☐ Develop exposure areas and exposure point concentrations (EPCs)
- ☐ Prepare TDSR for submittal in Q1 2017

Floodplain Soil

- ☐ Complete data validation and data quality/usability reviews
- ☐ Conduct spatial evaluation of floodplain soil data collected by Atlantic Richfield
- ☐ Estimate reference threshold concentrations for reference reaches
- ☐ Conduct comparison to risk-based screening levels
- ☐ Develop exposure areas and exposure point concentrations (EPCs)
- ☐ Prepare TDSR for submittal in late Q2 2017

Reporting Options

- ☐ Option 1 - Submit Sediment TDSR and Floodplain Soil TDSRs independently in Q1 and late Q2 2017, respectively
- ☐ Option 2 - Combine Sediment and Floodplain TDSRs into a single TDSR for submittal in late Q2 2017

RI/FS Field Work Status

Study Area		RI Data Collection Activity															
		Mapping/Field Verification	Drilling/Well Installation	Groundwater Monitoring	Mine Waste Soil Sampling	Floodplain Soil Sampling	Soil Sampling	Stream Sediment Sampling	Meteorological Monitoring	Surface Water Monitoring	Source Monitoring	SW / GW Interaction	Upper Tributary Characterization	Storm Water and Snowmelt Monitoring	Plant/Soil Sampling	Sediment Quality Triad	Fish Surveys and Sampling
On-Property Study Area		X	X	Q2 2018*	X	Q3 2018	X	X	X	X	X	Q4 2017	Q4 2017	Q4 2017*	X	X	X
Off-Property Study Area	Downstream Study Area	X				X		X		Q4 2017					X	X	X
	River Ranch	X					Q4 2017			X							
	East Fork Carson River	X					X			Q2 2017						X	
	Ore Piles	X					X										
	Leviathan Mine Road	X					X										
Reference Study Area		X	Q3 2017	Q2 2018*		X	X	X		X				Q4 2017*	X	X	X

X = Task complete (for select activities assumes 2 years monitoring sufficient)
= Task in progress (for select activities assumes 2 years monitoring needed per work plan)
= Task not started

Q1 = Quarter field work estimated to be complete (may change based on time required, weather conditions, and contractor availability).

* = Based on 2 years monitoring per work plan

RI/FS Field Work Status

FS Investigation/Study	Field Data Collection	Treatability Study	Monitoring
Geotechnical Investigation	Q2 2017*		Q3 2018
Revegetation Treatability Study	X	X	Q3 2018

X = Task complete
= Task in progress
= Task not started
Q1 = Quarter field work estimated to be complete (may change based on time required, weather conditions, and contractor availability).

RI/FS Field Work Status

PLACE HOLDER FOR SUMMARY OF WORK COMPLETED UNDER APPROVED AND CONDITIONAL APPROVED WORK PLANS AND TSAPS

RI/FS Field Work Status

PLACE HOLDER FOR WORK PLANNED FOR 2017